National Bureau of Standards

TECHNICAL NEWS BULLETIN

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World-Wide Observations of Solar Activity

As part of a broad program for the coordination and centralization of information on radio propagation, the National Bureau of Standards makes advance forecasts of poor or unusual conditions for short-wave radio reception. This service, performed by the NBS Central Radio Propagation Laboratory, is based in large part on the association of solar activity with unusual conditions in the ionosphere, the series of ionized layers in the upper atmosphere.

High-frequency radio waves—propagated over long distances by alternate reflections at the ground and in the ionosphere—are directly affected by ionospheric disturbances. NBS therefore carries on an intensive study of ionospheric conditions and related astronomical and geophysical phenomena. Material assistance is rendered this program through the cooperative efforts of solar astronomers scattered throughout the world, who transmit information to NBS on the development and progress of sunspots, solar eruptions, and other activity on the sun.

Because sunspots are rather easily observed, many terrestrial disturbances are popularly attributed to their presence. However, the sunspot is but one type of solar activity and actually represents a relatively cool area on the sun's surface. Spectroscopic observations show concentrations of extremely hot gases in the sun's atmosphere at places where there may be no spot at all or only a very small spot. These observations also locate regions where the speed of the sun's gases is unusually high or where there is an extraordinarily intense local magnetic field.

Although ionospheric disturbances, northern lights, magnetic storms, or bad radio reception cannot be attributed directly to sunspots, there is a close correlation between solar activity and these unusual terrestrial effects. The world-wide accumulation of information about the active regions on the sun—which may or may not contain a sunspot—greatly aids the NBS "radio weather" forecasters in anticipating interruptions to long-distance, short-wave radio communications.

The NBS forecasters must solve the problem of judging the degree of activity of the five, ten, or fifteen centers of activity that may exist on the sun at any one time. From past experience and results of research in the last 70 years, it is known that there is a tendency for the most active of these regions to be associated with radio propagation disturbances, usually when the region is nearest the center of the sun's disk. Since the sun rotates quite slowly—once in about 27 days—the forecasters ordinarily have several days to gage the activity of a region after it appears at the edge of the sun's disk, and then another few days in which to distribute their warning of the expected radio disturbance.

For accurate forecasts, the sun must be kept under constant observation; this means that cloudy weather must not be allowed to interfere with all observations

simultaneously. While solar observatories are relatively few in number, they are specialized and are scattered throughout the world. Some are located on mountain peaks to take advantage of the thinner atmosphere and clearer skies; others are situated near universities interested in solar physics, but usually away from dust-filled city atmospheres. This dispersal permits the sun to be continually under observation, for while clouds may obscure the sun over one observatory, the sky is usually clear over another.

Sunspot measurements are regularly reported to NBS from two observatories in the United States and another two in Europe. The U. S. Naval Observatory, only a mile from NBS, reports its measurements by telephone as soon as they are completed. Mt. Wilson Observatory has the advantage of the normally clear California weather. In Germany, the Wendelstein Observatory makes sunspot observations many hours before the sun rises in the United States; as a result of the cooperation of the U. S. Army Signal Corps, these sunspot reports are often the first to arrive in Washington. Sunspot observations made at Meudon, near Paris, come later in the day by radio broadcast. Cloudy skies are seldom experienced by all four of these observatories on the same day; thus, detailed information on sunspot activity is available to the forecasters almost every day. Ordinarily a single patrol observation each day provides sufficient data.

The more specialized observations of solar activity usually require better observing conditions than those needed for sunspot measurements. An example is finding the location and brightness of concentrated clouds of calcium gas in the sun's atmosphere, which is done at the McMath-Hulbert Observatory, near Pontiac, Michigan, and then telegraphed directly to NBS.

This network of observatories regularly supply NBS with information about solar activity. Domes indicate the optical observatories, towers denote the radio astronomers.

(1) NBS and Naval Observatory, Washington, D. C.; (2) Cornell University, New York; (3) McMath-Hulbert Observatory, Michigan; (4) Sacramento Peak, New Mexico; (5) Climax, Colorado; (6) Boulder, Colorado; (7) Mt. Wilson, California; (8) Greenwich, England; (9) Meudon, France; (10) Wendelstein, Germany; (11) Kanzelhohe, Austria; (12) Pic du Midi, Pyrenees; (13) Japan; (14) Australia; (15) India; (16) Sweden; (17) Italy.

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U. S. Department of Commerce

Charles Sawyer, *Secretary*

National Bureau of Standards
E. U. Condon, *Director*

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Contents

Mt. Wilson Observatory makes similar observations and, in addition, determines the polarity and intensity of sunspot magnetic fields from spectroscopic measurements.

Another important type of solar activity is the intense radiation from the sun's inner corona—the inner part of the sun's outer atmosphere. The corona is the most difficult of all solar phenomena to observe, making it necessary to locate observatories at high altitudes, where the sky is exceptionally free from dust and water vapor. Even though five widely separated observatories make such observations, there are frequently periods of several days during which reports of the emission regions of the corona cannot be obtained. Two of the coronal observatories are in the United States; one at Climax, Colorado, the other on Sacramento Peak, near Alamagordo, New Mexico. Climax is at an altitude of 11,500 feet, while the Sacramento Peak Observatory is 9,200 feet above sea level. Although these observatories are only 450 miles apart, they are in different meteorological areas. Coronal observations from Europe are also sent promptly to the CRPL Warning Service. The Wendelstein Observatory, on a pinnacle south of Munich, is a major contributor; another observatory, located on an iso-

lated mountain top in the Pyrenees, sends its observations to Paris, where they are broadcast to the Western Hemisphere.

French, German, and Japanese scientists engaged in radio forecasting have their own organizations for collecting and distributing solar data. As an example, the French radio regularly broadcasts its compiled information which includes, besides solar activity observations, data on the terrestrial phenomena sometimes associated with solar activity. The Bureau obtains information from these broadcasts as well as from similar broadcasts originating in Germany and Japan.

The new science of radio astronomy also plays a role in the evaluation of solar activity. Unfortunately, most radio telescopes cannot resolve a center of activity on the sun. Nevertheless, the variations in the amount of radio-frequency energy emitted by the sun as a whole are useful in evaluating its total activity. Once a day or oftener, Cornell University sends a telegram to NBS giving measurements of 200-megacycle radiation from the sun; similar measurements at other frequencies are reported by telephone from a National Bureau of Standards field station near Washington. Observations at still another frequency are included in the daily message from Paris.

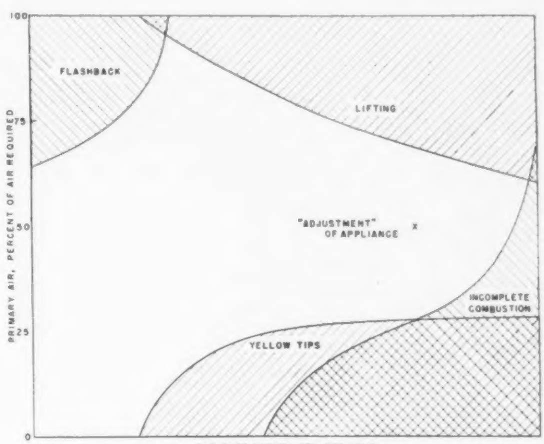
In all, seven solar observatories in the United States make both regular and special telephonic or telegraphic reports of unusual developments on the face of the sun to the NBS Radio Warning Service. Reports from an additional five solar observing stations in Europe arrive regularly at NBS by telegraph or radio every day. Observations of unusual phenomena are also received from time to time from these as well as the other major solar observatories of the world, which do not report regularly. The NBS forecaster is thus one of the best informed persons on this planet regarding the goings-on detected on the sun. A few of the world-wide observations are made specifically for the use of the National Bureau of Standards, but a large proportion of the data from the far-flung network of observatories is available to the Bureau as one of the many laboratories studying solar activity and its effects. NBS, in turn, makes available to interested users summaries of the data or information it receives, and warns scientific laboratories as well as communications agencies of the presence and possible effect of solar activity.

Predicting the Interchangeability of Fuel Gases

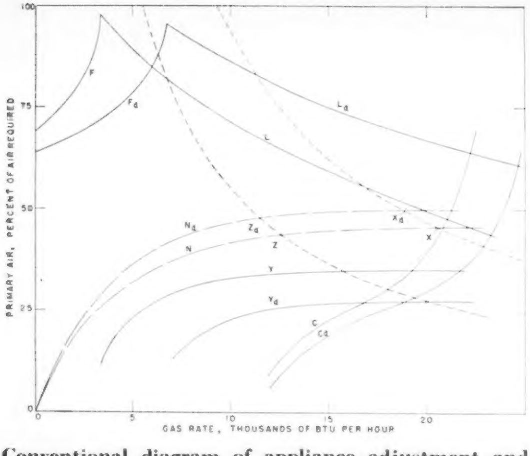
When gas-burning appliances have been adjusted for gas of one composition, flame characteristics will generally change if another kind of gas is substituted. While some substitutions will be entirely satisfactory, others will result in dangerous or unsatisfactory operation. For example, flames may go out, or carbon monoxide may be liberated. Because city gas systems must sometimes change from one source of supply to another, or must temporarily supplement their primary source to meet unusual conditions, it therefore becomes important to be able to predict the effect of a proposed change. Elmer R. Weaver, of the NBS gas chemistry laboratory, has recently formulated a new method for predicting the extent to which different gases will depart from exact interchangeability. Using six "indexes," four of them new and all easily computed from the gas composition, the NBS-Weaver gas interchangeability prediction method appears to be more accurate than any method hitherto proposed.

Gases are said to be "exactly interchangeable" when no difference can be seen or measured in the characteristics of the flames produced. When undesirable changes do not occur to a greater extent than is considered permissible, the gases are still called "interchangeable" or "practically interchangeable." No entirely satisfactory method has yet been found for predicting the extent of departure from exact interchangeability, although such a method is badly needed and a large amount of both theoretical and experimental work has been done in an effort to meet this need.

A gas flame may be unsatisfactory in several distinct respects. The flame may (1) blow away or "lift" from the burner ports; (2) "flash back" into the burner; (3) liberate enough soot to discolor surrounding objects (a condition that is more quickly judged by observing the yellow color of the flame than by watching for the appearance of actual soot); or (4) liberate carbon monoxide as a result of incomplete combustion. The four new interchangeability indexes of the NBS-Weaver method relate to these four phenomena: lifting, flash back, yellow tips, and incomplete combustion. The two old indexes incorporated in the new method concern rate of liberation of heat and supply of primary air. Two gases are interchangeable by the definition given above if they are interchangeable with respect



Conventional diagram showing appliance "adjustment" in relation to limits of satisfactory operation. When the point representing adjustment is within the unshaded area, the operation of the appliance is considered satisfactory.



Conventional diagram of appliance adjustment and performance, showing the effect of a change in gas composition.

If the point x_a (or z_a) represents the "adjustment" of an appliance with one gas, the adjustment with another gas will be represented by point x (or z) on or near the reciprocal curve (dotted) through x_a (or z_a). This assumes that neither the gas pressure nor the mechanical parts of the appliance are changed. If pressure is changed, the adjustment follows line N_a. Curves F_a, L_a, C_a, and Y_a represent the limits of satisfactory operation for the gas of initial adjustment with respect to flashback, lifting, incomplete combustion, and yellow tips; curves F, L, C, and Y represent the corresponding limits with the substitute gas.

to the first four indexes. However, the last two indexes must also enter into a consideration of the total effect of a change of gas supply.

Some of the early workers in the field sought unsuccessfully to arrive at a single rule or mathematical expression that would adequately embrace the several distinct aspects of interchangeability. A major step forward was made in 1946 when a committee of the American Gas Association abandoned the attempt to formulate a single satisfactory expression and adopted three separate indexes of interchangeability for lifting, flashback, and yellow tips. A fourth index to represent incomplete combustion was considered unnecessary at that time. This was because the experiments on which the AGA indexes were based showed gases to be practically interchangeable with respect to incomplete combustion if they were interchangeable with respect to each of the other three characteristics. These experiments, however, were made exclusively with appliances adjusted initially to burn natural gases.

Subsequently, the AGA conducted extensive experiments with appliances adjusted initially to burn a variety of manufactured gases, rather than natural gases. These experiments were much less successfully represented by the three AGA indexes. Pointing this out in its first report, the committee in charge of the tests expressed the hope that better formulas might be developed. The NBS-Weaver method has resulted from an attempt to develop such formulas.

The new indexes were derived in part from theory and in part empirically. In the process, data from the many thousands of both the earlier and later tests reported by the AGA were carefully plotted and tabulated. Derived with particular reference to these data, the NBS-Weaver indexes represent observed flame behavior more closely than any other indexes hitherto proposed. Nevertheless, although the new indexes are somewhat more accurate than their AGA counterparts, the use of either set of indexes affords a good basis for predicting the effect of a change of gas supply. The present study clearly demonstrates that no single formula for interchangeability compares in value with either the NBS or AGA set of separate indexes.

A contemplated gas change presents two questions. First, what will be the effect of the change on the several significant aspects of appliance operation: lifting, flash back, yellow tips, and incomplete combustion? In other words, will appliances as currently adjusted tend to operate more or less, satisfactorily in each of these respects, and by how much? Second, how much change is permissible? Interchangeability indexes can now answer the first question quite adequately. The second question, however, must be answered for each locality on the basis of available information as to existing adjustment of appliances. Depending on initial adjustment, some appliances will almost certainly burn less satisfactorily after a fuel change. Operation of differently adjusted appliances, on the other hand, may be improved by the same change.

For further technical details, see Formulas and graphs for representing the interchangeability of fuel gases, *by Elmer R. Weaver, J. Research NBS* **46,** 213 (1951) RP2193.

1951 Technical Session on Bone Char Research

The Second Biennial Technical Session on Bone Char Research was held on May 3 and 4 at the National Bureau of Standards in Washington, D. C. Sponsored jointly by NBS and the United States Cane Sugar Refiners' Bone Char Research Project, Inc., the Session was attended by representatives of sugar refiners and bone char manufacturers in Canada, Cuba, England, Scotland, Belgium, South Africa, and Australia, as well as the United States.

The 20 technical papers that were presented dealt with as many aspects of the problems of the industry. One-half day was devoted to each of the following subjects: test procedures, defecation preliminary to char filtration, the filtration cycle, and bone-char kilns. At a banquet held on the evening of May 3, a scroll honoring NBS on its fiftieth anniversary for its scientific achievements and "its investigations and publications in the fields of sugar chemistry and technology which have been unique and invaluable contributions to the sugar industry on a world-wide basis," was presented to Dr. E. U. Condon, Director of the National Bureau of Standards, by John W. Lowe, Vice President of the

Revere Sugar Refinery and the United Fruit Company and President pro tem of the Board of Directors of the Bone Char Research Project, Inc.

Because bone char is used in such enormous quantities in sugar refining, the success of the bone-char process depends largely upon the efficiency with which the char can be revivified so that it can be used many times. Prior to 1939, detailed basic knowledge of the bone-char process in sugar refining was very meager. To fill this need, a research program was initiated at the National Bureau of Standards for study of the fundamental nature of bone char and other solid adsorbents. Interest in the project has steadily increased until today industrial supporters of the work include almost all of the cane sugar refiners and bone-char manufacturers of the United States, as well as those in many other countries. The purpose of the Technical Session was to inform the industry of the present status of the research program and to permit informal discussion of problems of mutual interest.

The first morning session opened with a welcoming address by Dr. Condon, who outlined the principal functions of the divisions of NBS. The remainder of the morning was spent in a discussion of the 14 test procedures employed by the industry to control the bone-char process. The results of critical studies of these procedures over the last 2 years were summarized by referees representing the industry, who made specific recommendations based on considerations of standardization, uniformity, simplicity, and accuracy. Physical and chemical principles that could be utilized in the development of rapid test procedures were illustrated in laboratory demonstrations conducted by members of the NBS staff engaged in bone-char research. Discussion periods, which followed each referee's recommendation, were recorded to be entered in the official *Proceedings* of the Session.

Papers presented the first afternoon dealt with the various methods of clarification of raw-sugar liquors in the refining process. Phosphate defecation, kieselguhr filtration, and carbonatation were each treated by the staff of a refinery where that particular mode of clarification is practiced. Each procedure was shown to have both advantages and disadvantages; the choice of a method thus depends principally on the geographical location and the effect of local conditions on the economics of the process.

The morning meeting of May 4 was devoted to a discussion of the filtration of sugar liquors through bone char. More efficient use can be made of the bone char by employing a double filtration cycle in which the impure liquors flow first through a column of nearly spent char and then through freshly reactivated char. A method was described for determining the pressure required to obtain the desired flow of sugar liquor through bone-char filters. This pressure-flow correlation should prove very valuable in the design of char filtration systems in future refinery installations. Of particular interest was the description of pilot-plant apparatus for continuous "sweetening-off" and washing of bone char. The development of such apparatus on


The Sponsors of the Bone Char Research Project, Inc.
as representatives of the world cane sugar refining industry,
through the Project's Board of Directors.

— Congratulate —

The National Bureau of Standards
upon the occasion of its
Fiftieth Anniversary

and take this opportunity to commend:

Its outstanding achievements in science and engineering;

Its research and development of standards of measurement so essential to scientific techniques, to industrial progress, and to the general welfare;

Its investigations and publications in the field of sugar chemistry and technology which have been unique and invaluable contributions to the Sugar Industry on a world-wide basis:

And present this scroll on the occasion of the Second Technical Session on Bone Char at the National Bureau of Standards on the third day of May, 1951.

This scroll was presented to the National Bureau of Standards by the U. S. Cane Sugar Refiners' Bone Char Research Project, Inc., in honor of the Bureau's Fiftieth Anniversary.

a plant scale may very well lead to a continuous bone-char process in place of the present batch operation.

The second afternoon meeting dealt with the general subject of kilns for the revivification of bone char. A new kiln design was described, together with its accompanying drier, furnace, cooler, decarbonizer, and draw mechanism. The results of some promising experiments with revivification by superheated steam were presented, and the application of a rotary kiln to bone-char revivification was discussed. Other papers on kilns included a description of a new drier and the use of recording and controlling instruments in the char kilns.

Plaster Failures

Plaster failures exacting an annual toll of millions of dollars have long been a problem affecting owners of small homes and industrial and office buildings alike. Research at the National Bureau of Standards has shown that the majority of plaster failures result from expansion caused by the gradual combination of water with incompletely hydrated magnesia in the lime. Changes in the manufacture of the lime, as suggested by the NBS, have succeeded in reducing plaster failures to a minimum.

Investigation of Failures of White-Coat Plaster, BMS121, 42 pages, 25 cents, is available from the Government Printing Office, Washington 25, D. C.

A Photographic Film Dosimeter

A compact film badge has been developed by the National Bureau of Standards for industrial safety programs and for monitoring in civilian defense. The development, under the direction of Margarete Ehrlich of the NBS staff, resulted from investigations of X-ray effects on photographic film emulsions. The studies involved the effects of high-energy X-rays—ranging from those produced by constant exciting potentials of 50 kv to the radiation from a 10 Mev betatron—and included a determination of the sensitivity and energy dependence of the photographic emulsions.

Ideally, a film dosimeter should indicate the quantity of radiation or dosage, and, at the same time, be independent of the size of radiation quanta. Considerable effort was therefore expended in devising methods of compensating for the inherent energy dependence of the film. The NBS film badge, based on these considerations, is designed to monitor gamma and X-radiation in the quantum energy range from 120 kev to about 10 Mev. Although somewhat less accurate than other types of radiation meters, the badge is rugged and inexpensive, thus readily lending itself to large-quantity production.

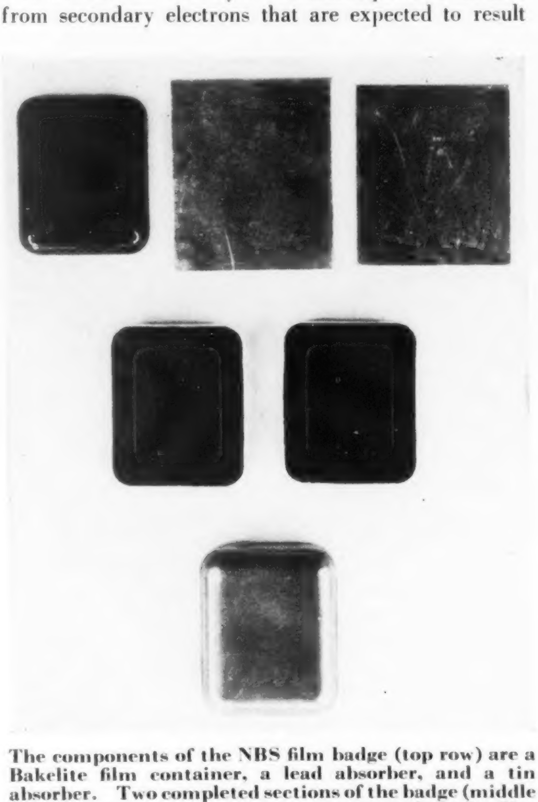
Personnel Monitoring

Current advances in the technology of atomic energy for civilian as well as military uses are bringing an increasing number of persons in contact with gamma and X-radiation. Even workers in the television industry—where the trend is toward larger screens and higher accelerating potentials—must be cautious in dealing with X-radiation produced in cathode-ray tubes. As more and more industries use radioactive materials in production, the problem of detecting radiation grows in complexity.

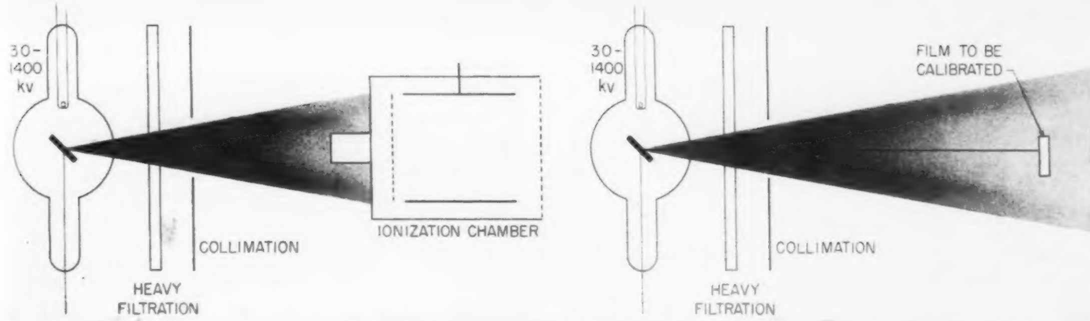
The maximum total dosage to which any part of the human body should be exposed continuously or intermittently in 1 week is currently set at 0.3 roentgen. The effect of a given dosage of radiation varies with the individual and with the nature of the radiation. Occasional exposure to a dose above the permissible limit may not be harmful. However, radiation exposure effects are cumulative, and a continuation of slight overexposures can become very dangerous. While Geiger-Müller counters and similar radiation meters are widely used, they are generally too cumbersome for periodic personnel-type monitoring. Film badges, on the other hand, by virtue of their small, compact size, are suited for this type of monitoring. Badges responding to dosages from 0.1 to 2 or more roentgens are made to be worn by workers in plants as continuous safety checks. At regular intervals the film is developed and the amount of radiation dosage for a given period of time is determined. Should there be an indication of dangerous over-exposure the wearer is warned, the necessary treatment is prescribed, and a survey is made to determine the source or cause of his over-exposure. The NBS film badge, designed as an industrial casualty and civilian defense monitor for radiation intensities from 0.5 to 10,000 roentgens, may be used to obtain a permanent record of the radiation exposures received by structures and individuals in critical areas resulting from industrial accidents or national disasters.

Film Characteristics

The use of photographic emulsions for gamma and X-ray dosimetry over wide ranges is complicated by the absorption characteristics of the silver bromide they contain. Because the film response is a maximum at quantum energies near the silver-bromide absorption edges, the low-energy radiation—which would show on the film 10 or more times as heavily as the high-energy radiation but is usually no more harmful to man—must be filtered through absorbers enclosing the film. The NBS film badge uses an absorber made of 1.07 mm of tin and 0.3 mm of lead placed over a Bakelite container 8.25 mm thick. The layer of Bakelite protects the film from secondary electrons that are expected to result



The components of the NBS film badge (top row) are a Bakelite film container, a lead absorber, and a tin absorber. Two completed sections of the badge (middle row) show the indentation to accommodate the film packet. An assembled badge is shown at the bottom.

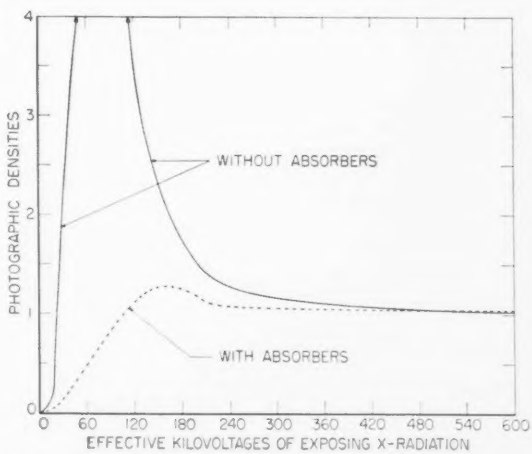


During the development of the NBS film badge, reference dosages were determined (left) by directing radiation through a heavy absorber of known characteristics, and into a free air ionization chamber. The response of the film to X-radiation can then be calibrated (right).

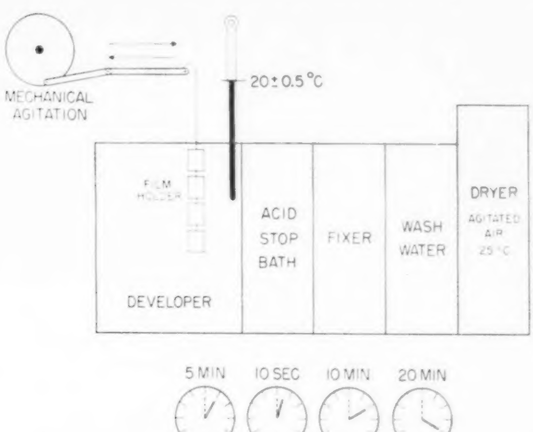
from more energetic gamma rays encountered in atomic energy work. A lead strip, approximately 0.78 mm thick, is wrapped around the periphery of the badge to guard against tangential radiation, as well as to cover the badge seam.

Before the NBS film badge could be constructed, two major problems had to be solved. The first of these was to select film emulsions that would detect dosages within the required range. The second was to devise means that would make the response of the emulsions independent of the extraneous electron flux and of the radiation energy.

Sixteen film emulsions were tested, and, of this group, four were selected that offered the lowest possible inaccuracies within the dosage range from 0.5 to 10,000 roentgens. The films were all exposed to X-rays with an effective potential of approximately 600 kev. This energy range was used because the response of the emulsions is essentially independent of the quantum



Effect of lead and tin absorbers on spectral sensitivity of a film in the NBS film badge. The absorber thicknesses chosen were found to represent the best compromise for all possible variations in radiation energy and film type.



To measure the extent of radiation exposure, the film is processed under controlled conditions. A similar procedure should be employed when using the NBS film badge for personnel monitoring.

energy of the incident radiation. Dupont films 510 and 605 and Eastman 5302 and double-coated 548–0 were chosen as most suitable in the dosage range of greatest biological interest.

In the course of the investigation, absorbers of different materials and thicknesses were exposed to radiation energies of carying potentials. In the final analysis of the resulting data, the tin and lead absorber thicknesses used in the NBS film badge were found to represent the best compromise for all possible variations in radiation energy and film type.

The film badges were calibrated with X-radiation energies from 115 kev to 10 Mev. The accuracy limits within the ranges from 1 to 40 roentgens and from 500 to 10,000 roentgens are ± 12 percent. In the center range, from 50 to 500 roentgens, the resulting limits are ±20 percent.

A High-Temperature Adhes

Printed electronic circuits—in which components and wiring are superimposed directly on insulating bases—are being used increasingly because of their adaptability to economical mass production and because they facilitate miniaturization of equipment. A major disadvantage of the printed circuit method, however, has been the difficulty of incorporating satisfactory resistors in the circuits. This difficulty has been largely overcome by an adhesive tape resistor method recently devised by B. L. Davis and associates of the National Bureau of Standards. The new resistor method was developed as part of a program of electronics research and development sponsored by the Navy Bureau of Aeronautics.

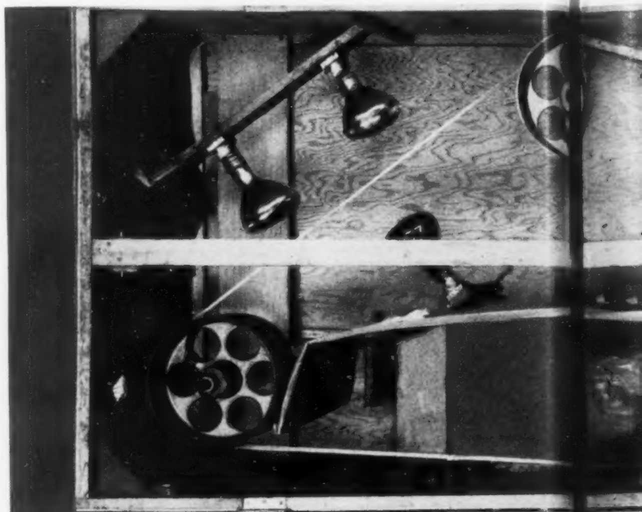
In this technique, circuits are first printed in narrow metallic bands on insulating bases, leaving a small gap at each point where a resistance is required; one of the self-adhesive resistors is then cut from a strip and pressed into position. Much better control of resistance values is possible than with previous printed resistor methods, and higher yields of acceptable assemblies are assured. The new method thus appears to combine the advantages of printed resistors and of separately manufactured resistors. The NBS tape resistor was developed to withstand the high temperatures of very compact equipment and operates satisfactorily at temperatures up to 200° C; in other electrical characteristics it is similar to present film-type carbon resistors.

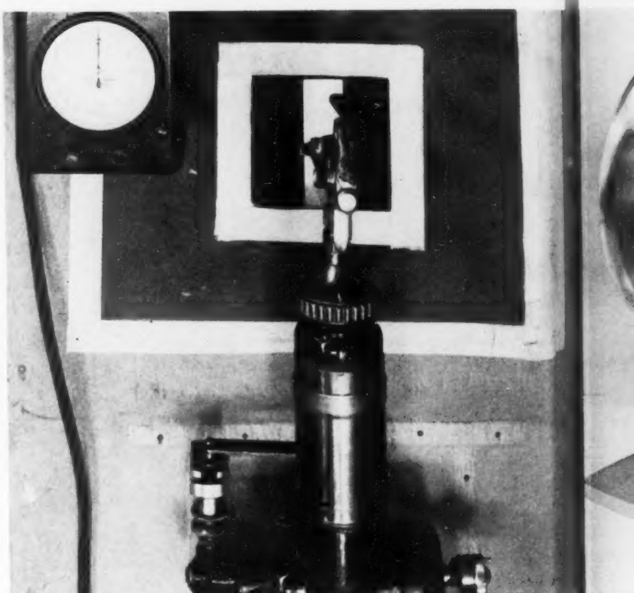
In the past, the usual method of introducing resistances into printed circuits has been to paint or spray a strip of resistance material directly on the base plate. The desired value of resistance is obtained by varying the composition and dimensions of the resistance strip laid down. Production of individual resistors to close tolerances by this direct-coating method is difficult, and the reduced probability of producing a number of satisfactory resistors on the same base plate greatly decreases the yield of acceptable assemblies.

Compositions and techniques used in making and applying the new tape resistors are remarkable for their simplicity. The resistor consists of a mixture of graphite or carbon black, resin, and solvent, applied in a thin layer to a thin roll of asbestos paper tape. The resistive coating is sufficiently adhesive to stick to an insulating base plate and to make satisfactory electrical contact with metallic terminals. When the resistor is in position, the resistance film is protected from abrasion and electrical shorts by its asbestos-tape backing. Resistor dimensions are kept constant; a variety of coating formulations give a range of values from about 100 ohms to 10 megohms.

The resistor is manufactured by spraying the resistance mixture onto a moving belt of tape. A thin (0.002 inch) protective film of polyethylene is lightly pressed over the resistance coating for protection in handling and storage; it is easily removed when the resistor is used. An electrically driven slitting machine quickly cuts the tapes into long strips of the desired width.

At present, the resistor tape, cut to width, is applied

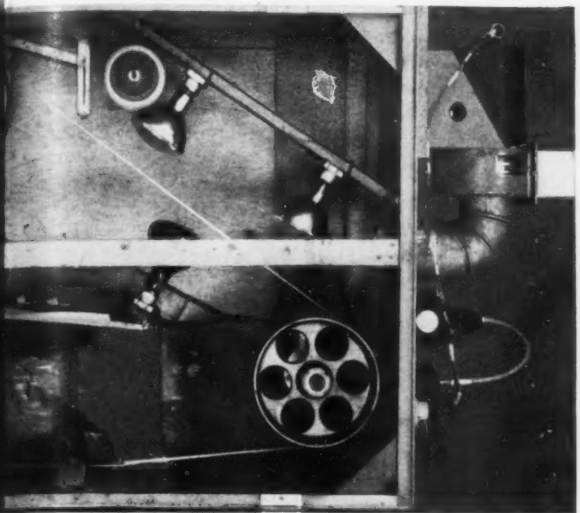




The resistive coating used in the NBS high-temperature adh pe resi the formulation onto an endless belt of asbestos paper tape. red hea of cabinet (lower left) showing spray gun. A specially de instru widths. Twelve disk knives mounted in pairs and spaced b ately

to printed circuitry by hand from a continuous spool; the tape is pressed into position and cut off with a razor blade. Plans call, however, for development of a device comparable to a wire stapler that will accept a roll of the resistor tape and apply and cut off a resistor of

ure dhesive Tape Resistor



e adh pe resistor is applied in this cabinet (top). A spray gun deposits tape. ed heat lamps accelerate evaporation of the solvent. End view lly de instrument (lower right) splits the resistor tape into desired ced b ately ground spacers, overlap slightly to give a scissors action.

l; or e- ll of

standard length each time a knob or handle is pressed.

Silicone resin is used for the binder-adhesive because of its suitability for high-temperature operation. Since the curing temperature of the silicone-resin formulations is high (300° C), and since curing is done after the resistors have been positioned in the circuit, the NBS tape resistor is at present applicable only to glass or ceramic base materials. However, enough work has been done with lower-curing resins to indicate definitely that they can be used in making tape resistors having cure temperatures low enough for application to some heat-resisting plastic materials. These resistors would be suitable for conventional operating temperatures.

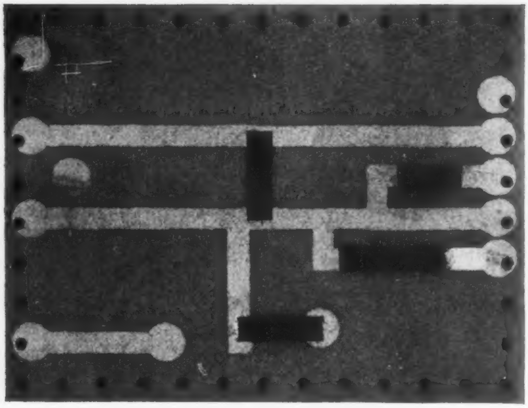
The possibility of varying resistor dimensions to obtain a range of values was considered but rejected. This so-called "aspect ratio" system has the advantage of reducing the number of formulations needed for a complete resistor range, but it complicates equipment design and production. Resistor dimensions were therefore standardized at a length of 0.5 inch (0.3-inch interelectrode distance) and a width of 0.13 inch $\pm$ 0.02 inch; this slight leeway in width permits some adjustment of resistor value in the slitting operation. With constant dimensions, wattage ratings are substantially independent of resistance value, and different contact resistance values due to different contact areas of silver and resistor are eliminated.

Both natural and synthetic graphites, as well as various carbon blacks, are used in the resistor formulations. Values of resistors are varied by changing the ratio of carbon to resin in the mixture and by using different carbons. The proportion of carbon to resin ranges from 10 to 50 percent; leaner mixtures have been found to give less favorable characteristics.

Tape resistors made from graphite mixtures have proved remarkably stable at ambient temperatures of 200° C. Another advantage of graphite formulations is that unusually low resistance values—down to about 100 ohms—can be obtained. Unfortunately, however, the useful upper limit of the graphite formulations seems to be about 5,000 ohms. Carbon blacks, which are less desirable at high temperatures, give values from 5,000 ohms to 10 megohms. Only a few carbon blacks have been found that yield tape resistors satisfactory for operation at 200° C. For most resistance ranges, however, carbon-black tapes have been made that are satisfactory at 170° C.

The coating formulation—carbon, resin, and solvent—is agitated with porcelain balls on a ball mill for at least 72 hours before it is sprayed on the tape. Spraying is done in a special cabinet. To secure a uniform coating, the tape, in the form of an endless belt 13 feet long and $1\frac{1}{4}$ inches wide, is moved rapidly past a spray gun many times as the spray mixture is slowly deposited. A number of infrared heat lamps, mounted within a few inches of the moving tape, hasten removal of solvent during spraying and dry the tape to the desired degree of stickiness after spraying is stopped.

The tape-slitting machine employs 12 disk knives mounted in pairs, slightly overlapping so as to give a scissors action and separated by accurately ground spacers. A small sample of the tape may be tested for value before the entire tape is slit. Testing is done by cutting the sample into a series of strips varying in



Typical printed circuit with new NBS adhesive tape resistors in place. In printing the pattern on the ceramic plate, a gap is left at each point requiring a resistance. The resistors are then pressed in position and cured by baking the whole plate.

width by 0.01 inch over the range 0.11 to 0.15 inch and making up a test plate from these strips. On the basis of test results, the slitter can be set to cut the entire roll into strips of the width necessary to give the desired final resistance value. A single belt of resistance tape yields approximately 1,500 resistors.

Proper curing of the resistors after application to the printed circuitry is extremely important. The curing process hardens the resistor, bonds it more firmly to the plate, and stabilizes its electrical characteristics. Although the optimum cure for different formulations differs considerably, a compromise cure of 4 hours at 300° C has proved satisfactory and has been adopted as standard. Curing is done in a temperature-controlled electric furnace to which an aluminum inner liner has been added to secure more uniform temperature distribution.

In using the resistors at 200° C, it has been found that those made from some formulations change sharply in value during the first 24 hours, then remain stable for several hundred hours. For this reason, there is some advantage in following the standard 4-hour cure at 300° with a 24-hour treatment at 200° C. As changes in the resin in the resistor film take place quite slowly at room temperature, the resistor tape may be stored for long periods. Its storage life may be further extended by refrigeration.

Testing and development of tape resistors are continuing at NBS. This work utilizes a test oven of special design that permits automatic recorded measurements to be made simultaneously on a large number of resistors without removal from the oven. Improved resistance formulations are being sought, particularly for certain ranges. Attempts are also being made to develop a satisfactory additional protective coating for application to the positioned resistor.

Combustion Efficiency of Jet Engines

Accurate data on the efficiency of the combustion process in jet engines are provided by a gravimetric method of exhaust-gas analysis recently developed by Fillmer W. Ruegg and Carl Halpern of the National Bureau of Standards. As the NBS procedure also supplies information on the nature of the components of the exhaust gas, it is expected to prove useful in the design and development of new types of combustion chambers for gas turbines and jet engines.

Fuel burned in jet combustion chambers releases energy that is converted either to thrust, to shaft horsepower, or to both, depending on the type of installation. The efficiency of the combustion process thus has a direct bearing on the over-all efficiency of the engine. While combustion efficiency can be calculated from observations of the temperatures and rates of flow of air, exhaust gas, and fuel, it is often difficult or impossible to make sufficiently accurate measurements of these quantities. The common methods of gas analysis have also proved unsatisfactory for this purpose because the fuel is burned with so much excess air that the concentration of the products of combustion is very low. To provide a more effective means for studying jet combustion efficiency, NBS therefore undertook to develop a reliable method of exhaust-gas analysis. Since analysis by weight gives precise results for small quantities, gravimetric methods were applied to the problem.

The NBS method aims primarily to determine the efficiency of the combustion process rather than to identify all constituents. Essentially it involves, first, the determination of the products of complete combustion (namely water and carbon dioxide) initially present in the sample and, second, determination of water and carbon dioxide obtained by oxidizing any combustibles remaining in the sample. All of the water and carbon dioxide initially present in the partially burned exhaust gas are first removed separately by absorption on solid reagents. The combustibles remaining in the gas are then burned completely in a quartz combustion tube, and the water and carbon dioxide thus formed are selectively absorbed as before. From the weights of carbon dioxide and water collected before and after complete combustion, the combustion efficiency of the jet engine can be calculated.

The sample of exhaust gas is first passed through a cold trap kept at −78° C, then through two absorption bottles containing Drierite and Ascarite respectively, where water and carbon dioxide are absorbed. Hydrocarbons, which would otherwise be adsorbed on the surface of the reagents used to absorb water and carbon dioxide, are condensed and remain in the cold trap. The remaining gases enter a quartz combustion tube containing copper oxide at 1,000° C. Here combustibles such as carbon monoxide, hydrogen, and methane are oxidized to water and carbon dioxide, which are

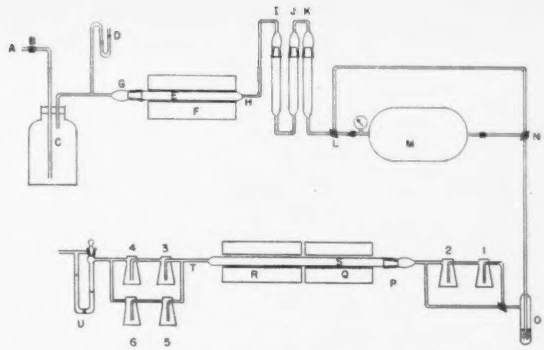
collected in absorption bottles containing Anhydrone and Ascarite. The condensate in the cold trap is then volatilized by gentle heating and flushed into the combustion tube by a stream of dry, carbon dioxide-free air. After complete combustion of these fuels, the resulting water and carbon dioxide are collected as before. The weights of water and carbon dioxide collected both before and after the combustion are obtained separately. In addition, a small portion of the sample is analyzed for its carbon monoxide content by use of the NBS Carbon Monoxide Indicator. (NBS Technical News Bulletin No. 354, 73 (Oct. 1946)).

The combustion efficiency is computed from the equation

$$\eta_b = 1 - \frac{W_1 + 1.50\,W_2}{W_3 + 1.50\,W_4}$$

when η_b is the combustion efficiency, W_1 is the weight of carbon dioxide determined by combustion of the combustibles in the exhaust, W_2 is the weight of water obtained from the unburned material, W_3 is the sum of the weights of carbon dioxide originally in the sample and that obtained from the combustibles, and W_4 is the weight of water originally in the sample plus the weight of water from the unburned material. While W_1, W_2, and W_3 are experimental values, W_4 is calculated from the total weight of carbon dioxide collected in the absorption bottles. Before substitution in the equation, W_1 is corrected for the carbon monoxide found to be present in the sample.

In studies of the method at NBS, several samples of known composition, containing substances typical of actual exhaust gas, were prepared and analyzed. Agreement between combustion efficiency calculated from the known composition and from the analytical



Schematic diagram of the apparatus used in the new gravimetric method for analysis of jet-engine exhaust gas.

A sample of exhaust gas from the container (*M*) enters the apparatus through stopcock (*N*). It then passes through the cold trap (*O*) to absorption bottles *1* and *2*. The portion of the sample that is not absorbed or condensed enters the combustion tube (*S*), which is surrounded by electric heaters (*Q*) and (*R*). Water and carbon dioxide produced by burning these gases in the combustion tube are absorbed in bottles *3*, *4*, *5*, and *6*. Dry, carbon-dioxide-free air for flushing the cold trap is supplied by the apparatus at upper left, consisting of the compressed air (at *A*), a control valve (*B*), a jar of activated alumina (*C*), a mercury manometer (*D*), a quartz combustion tube (*E*) containing copper oxide wire, an electric heater (*F*), and a series of absorption tubes (*I*, *J*, *K*). Rate of gas flow is determined by the flow meter (*U*).

data was excellent. In fact, in one large series of analyses, the combustion efficiency calculated from the analytical data agreed within 1 percent with that obtained from heat and flow measurements of the actual combustion chamber.

For further technical details, see Gravimetric analysis of exhaust gas from gas turbine combustion chambers, *by Fillmer W. Ruegg and Carl Halpern, J. Research NBS* **45**, 113 (1950) RP2117.

New Devices Speed Metal Fatigue Tests

Several devices recently constructed at the National Bureau of Standards are proving valuable in speeding metal fatigue tests in the NBS mechanical metallurgy laboratory. Developed by John A. Bennett and James L. Baker of the NBS staff, the new auxiliary test equipment includes devices for stopping the testing machine when a small crack forms in a specimen, an apparatus for the uniform polishing of fatigue-test specimens, and a machine for fatigue-testing thin sheet specimens in bending.

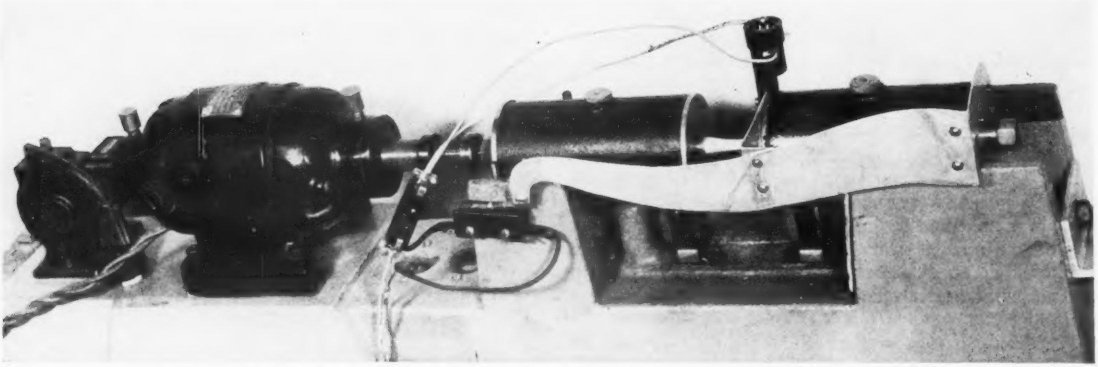
Because metal fatigue, or fracture under fluctuating stress, is the principal cause of service failure of machine parts, the laboratory study of fatigue of metals is of major importance. The continuing fatigue studies at NBS rely largely on commercially available testing machines. Occasionally, however, it is found necessary to supplement these machines with specially designed equipment such as the present new devices.

Devices for Stopping the Testing Machine

Fatigue fracture occurs in two stages. In the first stage the metal is subjected to fluctuating stress until a small crack forms. In the second stage, the crack grows until the remaining cross section of the member is too small to support the applied load, whereupon complete fracture takes place. In fatigue studies it is usually desirable to determine the number of cycles of stress required to start the crack, as well as the number to complete the fracture. These determinations are facilitated if the testing machine can be stopped automatically when a small crack forms. Two stopping devices for this purpose have recently been put into operation at NBS.

One commonly used fatigue-testing machine applies a bending moment to the specimen, simultaneously rotating it so that every point on its surface is subjected to a cycle that goes from tension to compression during each revolution. Used with standard commercial testing machines, the two NBS stopping devices respond to changes in the stiffness of the specimen when a small crack forms.

In a typical testing machine the specimen of 0.25-inch minimum diameter is drawn into spindles in



Newly developed automatic stopping devices installed on a fatigue-testing machine. The specimen is held between two weighted bearing boxes (right). The deflection-responsive stopping device consists of a microswitch (center) actuated by the lever rigidly attached to the right-hand bearing box. The vibration-responsive device (behind specimen) consists of a steel ball balanced on a pedestal; when vibration shakes the ball from the pedestal it closes the circuit.

bearing boxes. The bearing boxes are supported at the ends away from the specimen and loaded at the ends near the specimen by weights hung on shackles. This loading results in a deflection of the bearing boxes, and the deflection increases when a crack forms in the specimen. If the crack is only on one side of the specimen, the deflection will vary periodically with each revolution of the specimen; in other words, the bearing box will vibrate. Both the deflection and the vibration are used to actuate the NBS stopping devices; one device is deflection-responsive, and the other is vibration-responsive. The two stopping devices are used simultaneously at NBS, with their circuits connected in parallel; sometimes one will respond first, sometimes the other, depending on the peculiarities of the particular incipient crack.

The NBS deflection-responsive stopping device consists of a microswitch operated by a lever. The lever is fastened rigidly to one of the bearing boxes and at the other end carries an adjusting screw that bears on the actuating leaf of the microswitch. After the machine has run long enough to reach temperature equilibrium, the adjusting screw is advanced until a very small change in the position of the level will trip the microswitch and shut off the machine. With careful adjustment, the arrangement is sensitive to cracks having a length of as little as 5 to 10 percent of the circumference of the specimen.

The vibration-responsive stopping device, which is fastened rigidly to one of the bearing boxes, consists of a steel ball poised on a three-pronged pedestal. Vibration resulting from an incipient crack in one side of the specimen shakes the ball from its perch; in falling, the ball closes an electrical circuit that shuts off the machine. Sensitivity of the device may be adjusted by varying the distances of the pedestal prongs from each other.

Apparatus for Polishing Fatigue Test Specimens

The surface condition of test specimens has an important effect on fatigue and must therefore be made as uniform as possible. Two pieces of apparatus developed at the Bureau, both entirely automatic, make possible close duplication of the polishing operation from one specimen to the next.

In finishing specimens it is important that the direction of polishing be parallel to the direction of the stress to be applied in the fatigue test. This avoids stress concentration at the roots of the scratches. It is also important that abrasive pressure be light in order to avoid excessive cold-working of the surface. If these requirements are met, the surface need not be extremely smooth or highly polished.

Two types of specimens, smooth and notched, are used in NBS fatigue tests. The smooth specimens have test sections of 4-inch contour radius. The notched specimens, used when stress concentration is desired, have either a fillet of definite radius to each end of a cylindrical reduced section, or a circumferential groove with a semicircular root. If results with smooth and with notched specimens are to be compared, it is essential that the surface preparation of the two specimens be as much alike as possible.

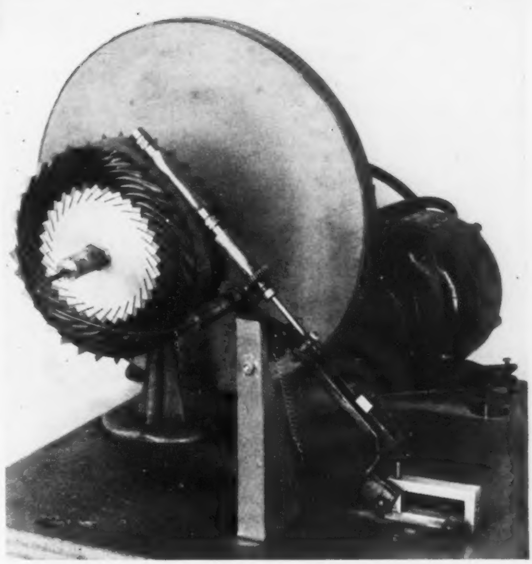
The machine for finishing smooth specimens consists essentially of three parts; a wheel carrying an abrasive belt, a means for supporting and rotating the specimen during the polishing operation, and a means for moving the specimen across the abrasive belt during polishing.

The wheel is distinctive in consisting of a large number of metal spring leaves, radiating outward from a hub, which press against the abrasive belt. This arrangement conforms the abrasive belt to the contour of the specimen and assures uniform abrasive pressure. The specimen is rotated at a rate that bears a constant relation (1 to 100) to the rotation of the abrasive wheel. Because the specimen is moved slowly across the abrasive belt, fresh abrasive is continually brought into use, resulting in a cutting rather than a rubbing action. A rubbing action is to be avoided, since it tends to produce more cold work in the specimen surface.

The apparatus for finishing notched (i. e., filleted or grooved) specimens is new only in a few details. It consists essentially of an abrasive-charged wire that rotates against the botton of the notch while the specimen is slowly rotated.

The specimen is held in a small bench lathe. A series motor, mounted on the cross-feed guide with its axis of rotation perpendicular to the axis of the specimen, drives the polishing wire through a short rubber coupling. A guide for the polishing wire is supported by a pivoted assembly above the working area, so that the weight of the guide holds the wire against the specimen. The abrasive, a thin air-agitated mixture of emery and water, is fed to the wire from a reservoir through a valve-controlled tube.

The motor that drives the polishing wire also drives the headstock of the lathe through a 100-to-1 reducing gear. By keeping motor speed and polishing time constant, as well as the ratio of wire speed to specimen speed, high uniformity of finish is assured. Moreover, the finish is very similar to that produced by the machine for finishing smooth specimens.



Apparatus used for polishing fatigue test specimens produces a highly uniform specimen. The polishing wheel, consisting of a number of metal spring leaves, presses an abrasive belt against the specimen with uniform pressure. The specimen rotates at a constant rate and advances slowly over the abrasive surface.

Fatigue Testing Machine for Thin Sheet Specimens

Because of the large deflection required, sheet metal of less than about 0.015-inch thickness cannot be fatigue-tested in bending on commercially available testing machines of the cantilever type. By deflecting the specimen as a column, a newly developed NBS fatigue-testing machine makes possible the bending of specimens to a small radius of curvature without large amplitudes of motion in the driving mechanism. Because the machine holds several specimens at once, considerable testing time may be saved.

The new thin-sheet fatigue tester was adapted from a Krouse Plate Bending Fatigue Machine. Specimens 1 inch high by ½ inch wide are held in place by grooves in two horizontal arms. While the lower arm remains stationary, the upper arm, pivoted at one end, is moved up and down at the other end by a crank arm and adjustable eccentric. At the top of the crank throw the arms are parallel, and the distance between the grooves equals the length of the specimens. When the upper arm is moved down by the crank, the specimens are loaded as columns and assume bowed positions. Bending is greatest, of course, for the specimen nearest the crank.

An automatic stopping device used with the machine takes advantage of the fact that after a crack forms, the specimen no longer deflects in a smooth curve. An adjustable contact assembly is clamped to the lower arm of the machine and adjusted so that the intact specimen nearest the crank just fails to touch the contact disk at its maximum deflection. Cracks tend to form near the center of the specimen, and when a crack starts, a "hinge effect" causes the middle of the specimen to deflect more and make contact with the disk. This contact operates an electronic relay, stopping the machine.

When a group of identical specimens are set up in the machine, the one nearest the crank, since it is subjected to the highest range of stress, will break first. After this specimen has been removed and the number of cycles recorded, the contact assembly is moved to the next specimen and the machine restarted. Since as many as seven specimens can be tested at once, the fatigue properties of a material can be determined over a wide range of maximum strain values in a relatively short time.

Electrochemical Society Meets at NBS

The Electrochemical Society held its ninety-ninth convention in Washington, D. C., April 8 to 12, in conjunction with the fiftieth anniversary of the National Bureau of Standards. An audience of 600 scientists and technologists in various phases of electrochemistry heard 120 papers in the fields of electronics, luminescence, rare metals, electrothermics, theoretical electrochemistry, and industrial electrical insulation. Dr. William Blum, Chief of the NBS Electrodeposition Section, served as the Honorary Chairman, and Paul L. Howard, of the NBS Electrochemistry Section, was General Chairman.

The Electrochemical Society, Incorporated
extends
GREETINGS
to the National Bureau of Standards
upon the occasion of the Bureau's
Fiftieth Anniversary 1951
CONGRATULATIONS

upon the bureau's outstanding accomplishments in science and engineering: its fundamental research and its applied research and development in the physical sciences; its development of scientific standards of measurement and services related thereto needed by science, industry, commerce, Government and the public of the United States; its pioneering studies of the properties of materials and of physical constants; its splendid achievements in developments critical to the National defense; its contributions to economy in the operations of the Government;

and Presents
THIS SCROLL

on this 9th day of APRIL in the year 1951 at the annual meeting of the Electrochemical Society, Incorporated, held at Washington, D.C., in recognition of the Fiftieth Anniversary of the Bureau of Standards.

Charles L. Faust
President

The Electrochemical Society presented this scroll to the National Bureau of Standards on the occasion of the Bureau's Fiftieth Anniversary.

Among the outstanding papers were those on "Glass-fiber paper manufacturing," by B. W. Schibner (NBS); "Manufacture and properties of ozone," by Clark E. Thorp (Armour Research Institute); and "New luminescent materials," delivered by G. L. Putman (University of Washington).

The Faraday Society of England was officially represented at the meeting by Dr. J. O'M. Bockris of the Imperial College of Science and Technology. Dr. Bockris received the Richard's Memorial Award, which is presented by the Electrochemical Society for notable contributions to the science of electrochemistry. His Richard's Memorial Lecture was "Hydrogen overvoltage."

At the society luncheon, a scroll congratulating the National Bureau of Standards on 50 years of contribution to science and industry was presented by Dr. Charles L. Faust, president of the Electrochemical Society, to Dr. E. U. Condon, Director of the NBS. Dr. Condon's response included a discussion of current research activities at the NBS.

Following the presidential banquet, the Young Author's Prize was awarded to George W. Murphy (University of Wisconsin) and the Turner Book Prize to Paul Delahay (Louisiana State University). Dr. Charles L. Faust (Battelle Memorial Institute) delivered the presidential address as the retiring president. Dr. R. M. Hunter (Dow Chemical Co.) was installed as President and Marvin G. Udy as the newly elected third Vice-President. Dr. J. C. Werner (President of Carnegie Institute of Technology) is the senior Vice-President; R. J. McKay (International Nickel Co.), second Vice-President; Dr. H. B. Linford (Columbia University), Secretary; and E. G. Widell (Radio Corporation of America), Treasurer.

Included on the program were tours of NBS laboratories, where Society members observed typical activities in plastics, textiles, building technology, dental research, electronic instrumentation, high voltage and X-rays, and radio-frequency standards, in addition to such specific developments as the impregnation of leather with rubber, the magnetic fluid clutch, and the NBS electronic computer, SEAC.

Symposium on the Mechanical Properties of Metals at Low Temperatures

More than 150 leading metallurgists and metallurgical engineers attended the NBS Semicentennial Symposium on the Mechanical Properties of Metals at Low Temperatures held at the National Bureau of Standards in Washington, D. C., on May 14 and 15, 1951. The symposium was held in celebration of the fiftieth anniversary of the NBS, and papers were presented by representatives of industry, universities, and the government discussing recent research. The program was under the joint chairmanship of Thomas G. Digges and George A. Ellinger of the NBS Metallurgy Division.

A knowledge of the mechanical behavior of metals at low temperatures is of vital importance to an understanding of their rheological properties and to their successful application in low-temperature service. The engineering applications of metals at low temperatures are constantly increasing in industry, as evidenced by the rapid growth of the refrigeration industries, and the increasing demand for the liquefaction of many gases, their transportation and storage. Armed Services equipment, such as airplanes, weapons, and transportation vehicles, frequently must operate at low temperatures. Embrittlement of metals in cold atmospheres is a sources of concern to designers, manufacturers and users.

The opening paper, "Mechanical properties of high-purity iron-carbon alloys at low temperatures" by R. L. Smith, Professor G. A. Moore, and Professor R. M. Brick (University of Pennsylvania), summarized the effects of carbon content within the range of 0.05 to

0.5 percent of carbon, at temperatures from $-185°$ C to room temperature, on tensile properties and on natural stress-strain curves. Increases in carbon content resulted in increases in stresses at yield points, in flow stresses at constant strain and constant temperature, and in fracture stresses. Decreases were noted in total strain at fracture. The transition temperature, based on the energy required to fracture tensile specimens, is about $-160°$ to $-170°$ C and is independent of the carbon within the above range.

A paper, "Brittle fracture in ship plates," presented by Dr. M. L. Williams (National Bureau of Standards), showed that although failures had been reduced by improvement in design details and welding workmanship, many failures were traceable to the quality of steel, especially with respect to the notch sensitivity as measured by the 15 ft-lb transition temperature in Charpy **V**-notch tests. Notch sensitivity was found to increase with increased carbon, phosphorus, molybdenum, or arsenic content and grain size and to decrease with increases in silicon, manganese, copper, or nickel content. The combined effects of these elements were shown not to be simply additive.

Dr. N. P. Allen (National Physical Laboratory, Eng.) described "Recent European work on the mechanical properties of metals at low temperatures." An account was given of research in Europe since 1940, including the effect of low temperatures on the following: Behavior of common engineering metals and alloys, elastic constants, mechanisms of slip, brittle fractures of ferritic alloy steels as affected by alloy content, heat treatment, and similar variables. Special attention was given by Dr. Allen to work at the National Physical Laboratory on the effect of carbon, oxygen, manganese, and combinations of these elements on the low-temperature properties of high-purity iron (99.96% Fe).

A discussion of "The manufacture of steels for low-temperature service" by Dr. J. B. Austin (U. S. Steel Co.) pointed out many of the salient factors necessary for the production and processing of steels suitable for low-temperature service. Among these were fine grain size, suitable microstructure in ferritic steels, a tempered martensitic structure of desired hardness level is preferable to a pearlitic structure of the same hardness level); complete deoxidation of steel, preferably with aluminum, and addition of certain alloying elements. The choice and amount of the beneficial alloying elements, however, depends upon precise service conditions and economic factors, such as availability and cost.

A paper on the "Development and application of chromium-copper-nickel steel for low-temperature service" by Walter Crafts and C. M. Offenhauer (Union Carbide and Carbon Research Laboratories, Inc.) presented data showing how a normalized low-alloy steel suitable for low-temperature service down to $-100°$ C was developed by addition of approximately one-half percent each of manganese, copper, nickel, and chromium. Emphasis was placed on the beneficial effect of deoxidation with aluminum to assure fine grain size. Increasing the residual aluminum content to approximately 0.2 percent gives an additional improvement, thus producing a steel suitable for use at slightly lower temperatures.

A study of "The properties of austenitic stainless steels at low temperatures" was given by Dr. V. N. Krivobok (International Nickel Co., Inc.). Data on the effect of low temperatures on the modulus of elasticity, ductility, fatigue impact, tensile impact, tension, and other mechanical properties were summarized. The effect of cold-working at low temperatures and the beneficial effect of low temperatures on ductility characteristics were discussed in detail. The beneficial influence of the low carbon content of these alloy steels on their mechanical properties at low temperatures was also described.

A paper on the "Application of metals in aircraft at low temperatures" by J. B. Johnson and D. A. Shinn (Wright-Patterson Air Force Base) discussed briefly the relationship of the properties of metals as determined by conventional laboratory tests and those selected by the designer. Data on tests of aircraft metals at temperatures down to $-420°$ F were presented. The selection of a steel with a higher content of strategic alloying element than is necessary for the specific application was discouraged.

Professors C. W. MacGregor and N. Grossman (Massachusetts Institute of Technology) in their paper on "Dimensional effects in fracture" discussed the influence of specimen size and the effect of various ratios of combined stresses on the transition temperature from ductile to brittle fracture. Slow bend tests at various temperatures with flat circular disks of 0.95-percent carbon steel simply supported around the circumference and loaded by a concentric force at the center indicated that the size effect in ratio ranges of 6 to 1 was insignificant when similitude of specimens and test conditions was maintained. Other experimental data indicated that the transition temperature of this steel increased about 60 deg F as the biaxial stress ratio was varied from 0.483 to 1.0.

The closing paper, "Tensile properties of copper, nickel and some copper-nickel alloys at low temperatures" by G. W. Geil and N. L. Carwile (NBS), discussed the results of tension tests made at temperatures ranging from $+100°$ to $-196°$ C. Graphs of true stress vs strain did not exhibit the commonly accepted parabolic relationship. The initial and ultimate strengths, true stresses at maximum load and at initial fracture, were shown to increase continuously with decrease in temperature. The true strain at maximum load increased slightly with decrease in temperature, but no significant change in the strain at fracture was observed. The rates of work hardening at specific true strains, in general, increased with decrease in temperature and, in the case of the alloys, were affected greatly by their compositions.

An interesting motion picture on the transformation of white (β) tin to the grey (α) form at $-20°$ C was shown. This picture was filmed by the University of Pennsylvania and narrated by Dr. M. J. Disckind (Franklin Institute).

New NBS Laboratories Established at Corona

The new National Bureau of Standards laboratory center at Corona, California, to be devoted to various phases of electronic research, development, and engineering, will be primarily concerned with technical problems of importance to the Department of Defense. Dr. R. D. Huntoon, formerly Chief of the NBS Atomic and Radiation Physics Division, has been named Associate Director to head the new laboratories, which are expected to commence limited operations in June and be in essentially full-scale operation by September. The site is near other important research centers, particularly the Navy installations at Inyokern, and Pt. Mugu and the aircraft industries in the Los Angeles area.

In the near future the most important activity at the Corona laboratories will be the development of guided missiles. An analog computer is being set up in the laboratories to be used in flight simulation problems where trajectories of guided missiles must be computed mathematically. Some of the existing buildings are now being remodeled to house electronic laboratories, the large computer, machine shops, a wind tunnel, cells for testing jet-engines, altitude chambers, a missile assembly section, and a technical library.

Publications of the National Bureau of Standards

Periodicals

Journal of Research of the National Bureau of Standards, volume **46**, number 6, June 1951 (RP2212 to RP2219, incl.). 75 cents.

Technical News Bulletin, volume **35**, number 6, June 1951. 10 cents.

CRPL–D82. Basic Radio Propagation Predictions for September 1951. Three months in advance. Issued June 1951. 10 cents.

Research Papers

Reprints from Journal of Research, volume 46, number 5, May 1951.

RP2205. Acidic dissociation constant and related thermodynamic quantities for monoethanolammonium iron in water from 0° to 50° C. Roger G. Bates and Gladys D. Pinching. 10 cents.

RP2206. Ultraviolet spectral distribution of radiant energy from the sun. Ralph Stair. 10 cents.

RP2207. Wind tides in small closed channels. Garbis H. Keulegan. 15 cents.

RP2208. Infrared spectrum of bromochlorofluoromethane. Earle K. Plyler and Mary A. Lamb. 10 cents.

RP2209. Surface tension of molten alkali silicates. Leo Shartsis and Sam Spinner. 10 cents.

RP2210. Mechanism of the degradation of polyamides. Bernard G. Achhammer, Frank W. Reinhart, and Gordon M. Kline. 20 cents.

RP2211. Radiation properties of spherical antennas as a function of the location of the driving force. Philip R. Karr. 10 cents.

Applied Mathematics Series

AMS7. Tables to facilitate sequential *t*-tests. 45 cents.

AMS11. Table of arctangents of rational numbers. John Todd. $1.50.

Building Materials and Structures Reports

BMS123. Fire tests of wood-framed walls and partitions with asbestos-cement facings. Nolan D. Mitchell. 15 cents.

BMS124. Fire tests of steel columns protected with siliceous aggregate concrete. Nolan D. Mitchell. 15 cents.

Circulars

C508. Reference tables for thermocouples. Henry Shenker, John I. Lauritzen, Jr., and Robert J. Corruccini. 35 cents.

Miscellaneous Publications

M197. Fire tests of bulb-type carbon-tetrachloride fire extinguishers. 10 cents.

Publications in Other Journals

Mold growth and the pH of tartrate buffer solutions. Roger G. Bates. Anal. Chem. (1155 Sixteenth Street NW, Washington 6, D. C.) **23**, 813 (1951).

Determination of dissociation constants in a mixture of two weak acids by electromotive force measurements. Roger G. Bates. J. Am. Chem. Soc. (1155 Sixteenth Street NW, Washington 6, D. C.) **73**, 2259 (1951).

The determination of freezing point of engine antifreezes. R. E. Mallonee and F. L. Howard. ASTM Bulletin (1916 Race Street, Philadelphia, Pa.) No. 172, p. 43 (Feb. 1951).

Grease consistometer is modified to operate at constant shear rates, higher viscosities. H. W. White. Petroleum Processing (1213 West 3rd Street, Cleveland 13, Ohio) **6**, 285 (1951).

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